Di-γ Transverse Momentum in H-> $\gamma\gamma$ Analysis

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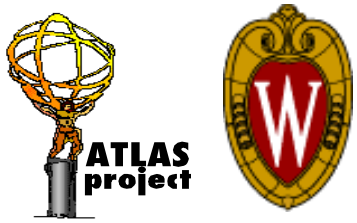


Higgs WG meeting 22/01/04

Outline

- Introduction
- Transverse momentum in Signal
  - MC@NLO
- Transverse momentum for irreducible background
  - ResBos
- Transverse momentum for reducible backgrounds
- Conclusions: Strategy for H->γγ analysis
  - Inclusive versus H+jets analyses

Introduction

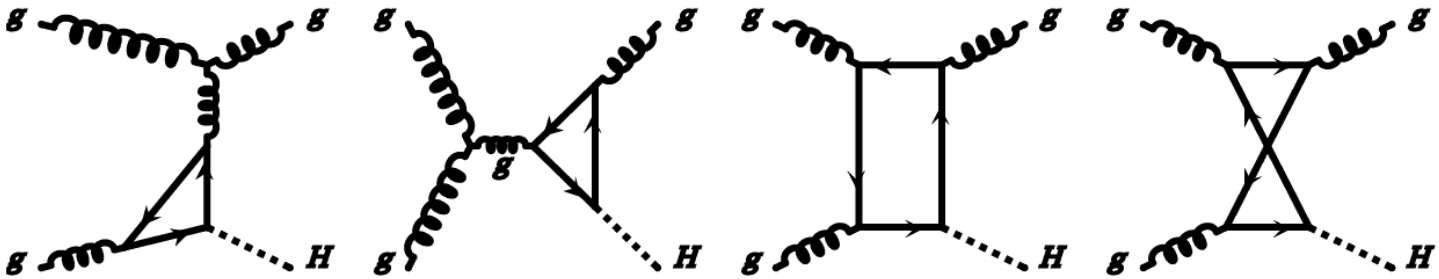
- Publicity plots report on inclusive H->γγ analysis only
  - Used only γγ invariant mass as discriminating variable
    - Di-γ transverse momentum may also be used
      - Need to look into a more global analysis like the one performed for H->ZZ->4l
  - Results from H+1jet and H+2jet analyses have not been included
    - Need to establish combination procedure: avoid double counting and take into account correlated systematic errors
  - Need to apply QCD higher order corrections and re-summation effects, wherever available for both signal and background

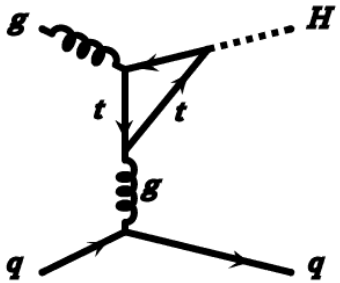
Introduction (cont)

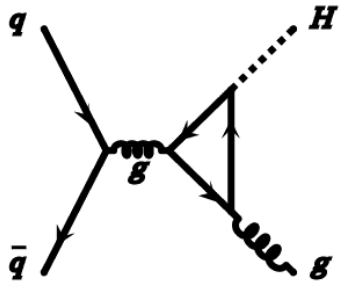
- A lot of progress is available or is underway
  - Know impact of new detector layout (F.Tartareli et al.)
  - QCD higher order corrections are available for inclusive and H+1jet analyses for both signal and background (see G.Unal for overview).
  - Re-summation (+QCD higher order corrections) are available for a number of processes: some of these are implemented in MC's, some may be incorporated "by hand" (M.Escalier/Wisconsin)
  - We understand the impact of H+jets analyses (Zmushko/Japan/Wisconsin)
  - Re-evaluation of reducible backgrounds is underway (M.Wielers/Orsay/Wisconsin)
  - Combination tools for LHC are available (F.Cerutti/Wisconsin)

Signal

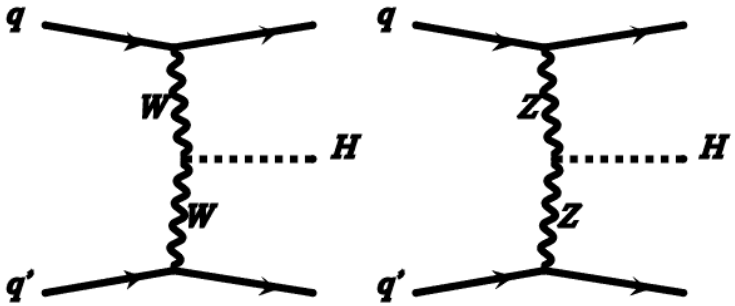
pp→H+X (MC@NLO)





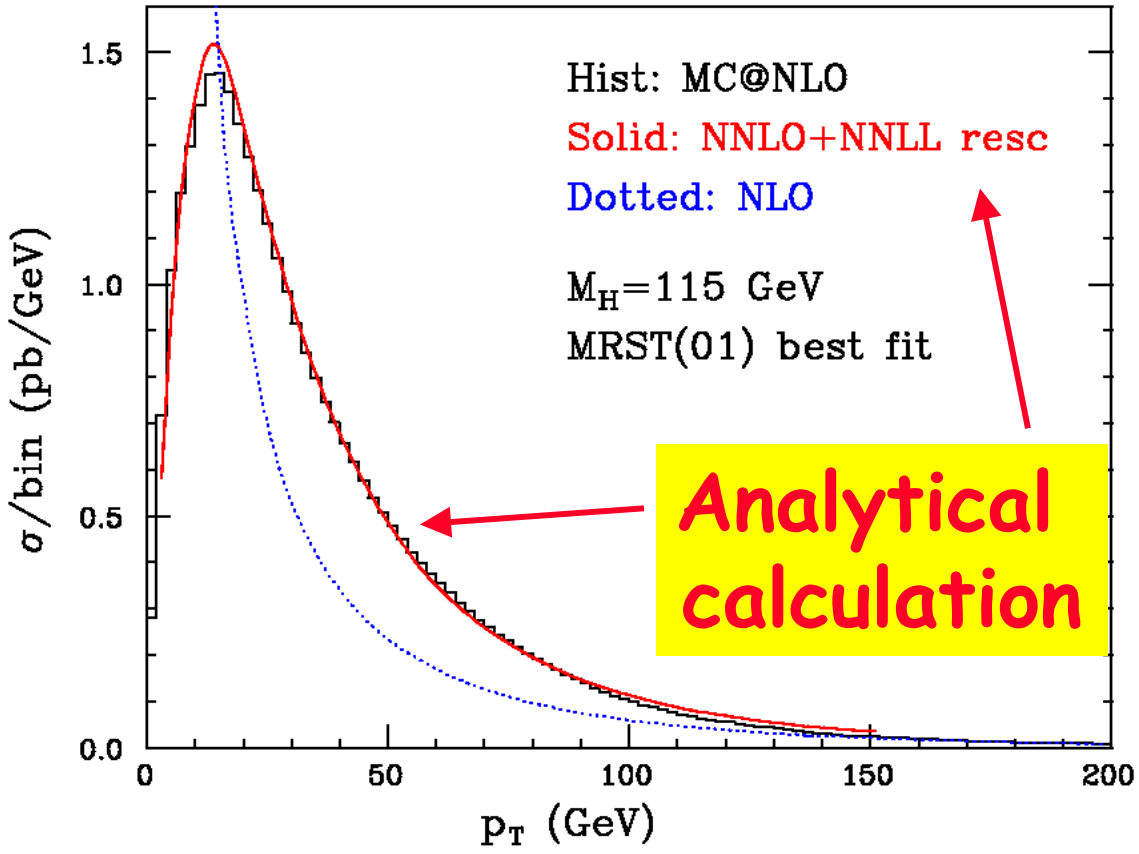


VBF (PYTHIA)



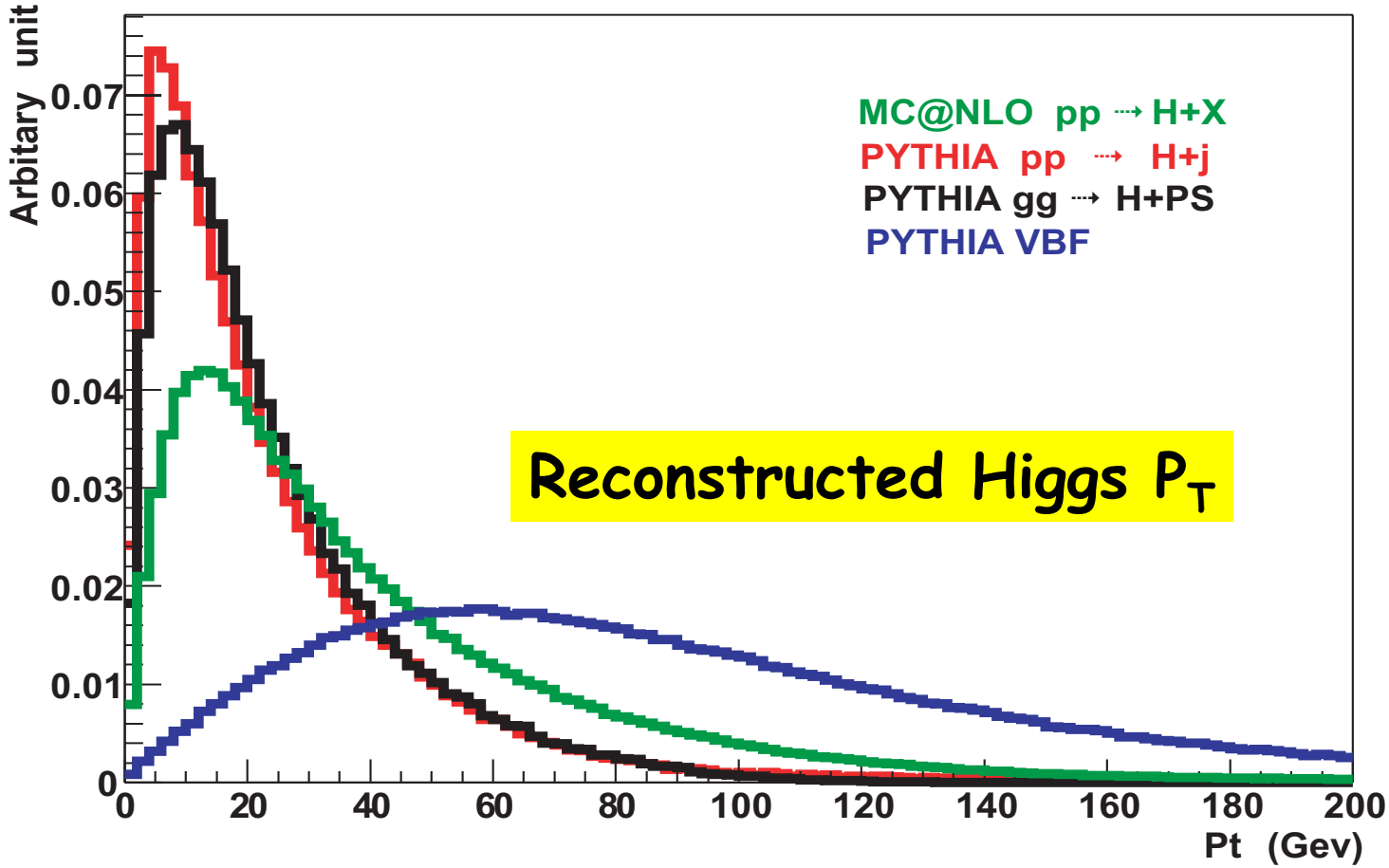
Signal (cont)

- MC@NLO (matrix elements matched to standard parton shower) agrees very well with analytical calculation (matrix elements and re-summed terms merged analytically)



Signal (cont)

- PYTHIA gives a significantly softer spectrum compared to MC@NLO and analytical calculation

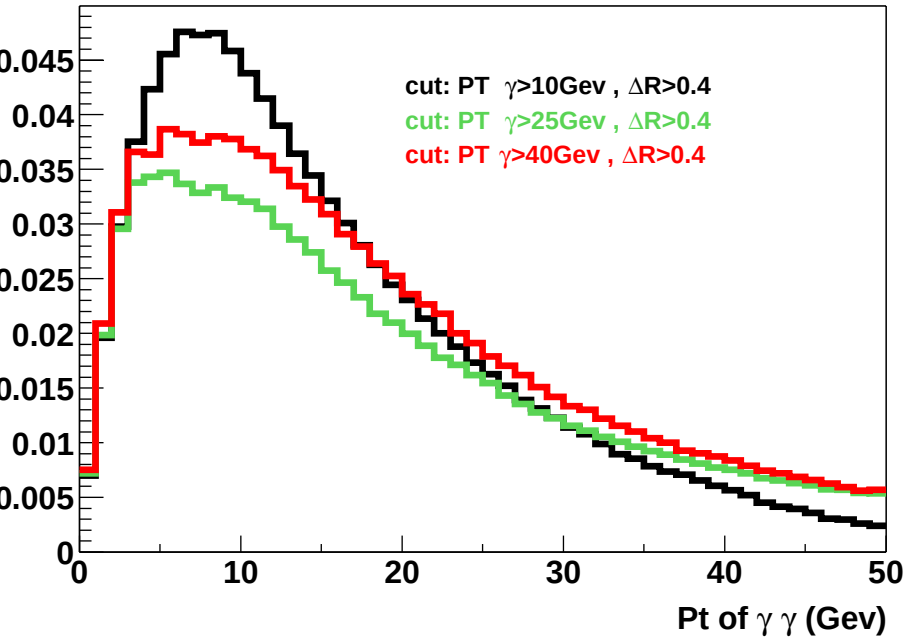


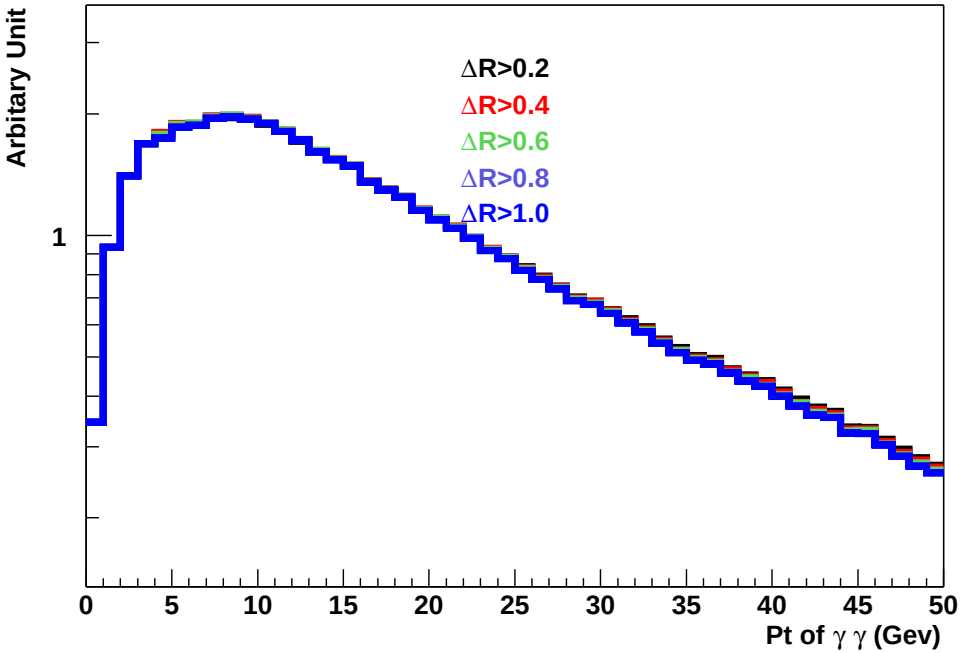
$\gamma\gamma$ Irreducible Background

- Real $\gamma\gamma$ production ($qq \rightarrow \gamma\gamma$ and $gg \rightarrow \gamma\gamma$) is known to NLO. However, it has not jet been implemented in MC@NLO (may be done in the future, though)
- We have LO matrix elements interfaced with parton shower (Pythia, Herwig)
- Semi-inclusive MC (not an event generator) with NLO matrix elements matched to soft/collinear gluon re-summation: ResBos
  - Since it is not an event generator we need to come up with some practical solution. The most obvious one is to study the perspectives of re-weighting Pythia

ResBos

- Di-γ deppends somehow on cuts on $P_{T\gamma}$ and is almost insensitive to $\Delta R_{\gamma\gamma}$ separation
  - $P_{T\gamma\gamma}$ and $P_{T\gamma}$ correlation drops with increasing $P_{T\gamma}$





ResBos vs. Pythia

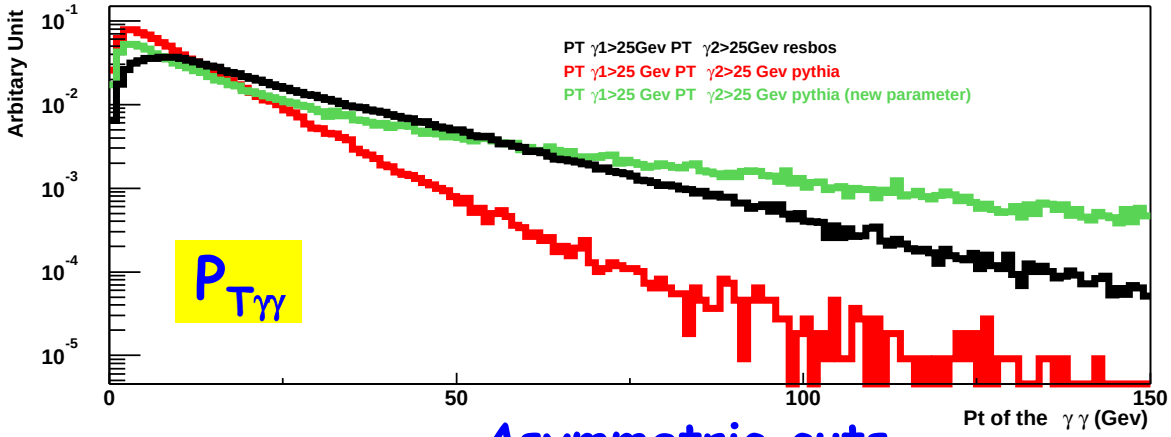
- $P_{T\gamma\gamma}$: Resbos is compared with nominal Pythia and Pythia with MSTP(68)=2

ResBos

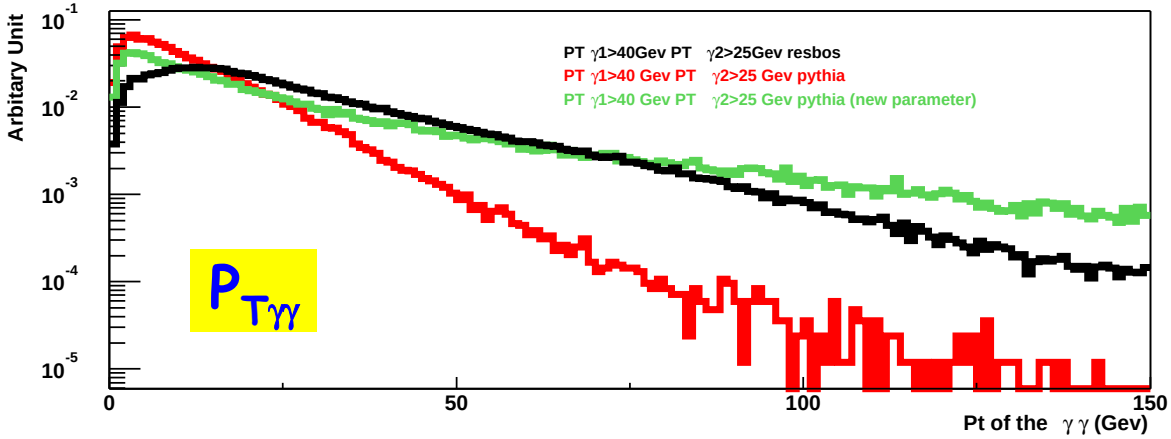
Pythia (Nominal)

Pythia (MSTP(68)=2)

Symmetric cuts



Asymmetric cuts



ResBos vs. Pythia

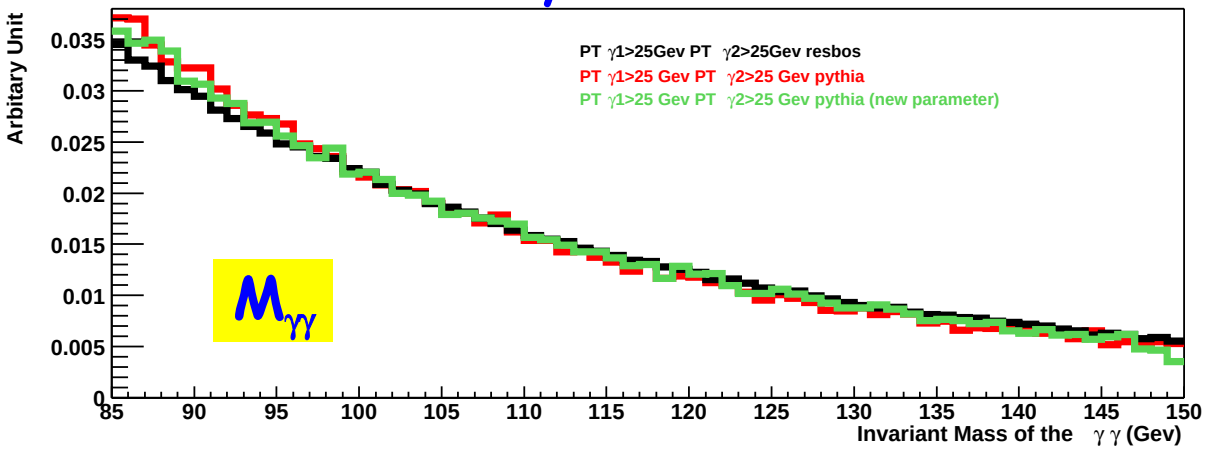
- $M_{\gamma\gamma}$: Resbos is compared with nominal Pythia and Pythia with MSTP(68)=2

ResBos

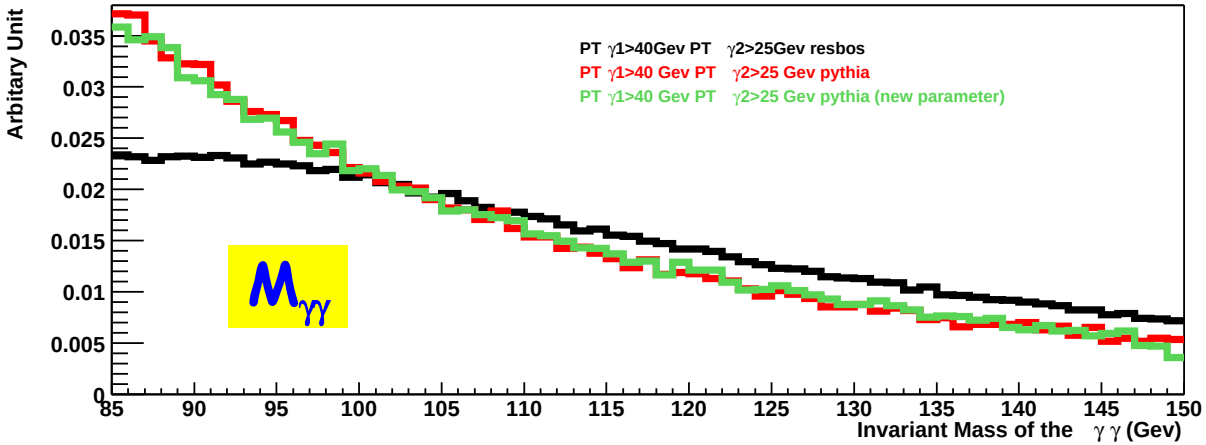
Pythia (Nominal)

Pythia (MSTP(68)=2)

Symmetric cuts



Asymmetric cuts



P_T for reducible backgrounds

- Impact of reducible backgrounds (γj, jj) depends strongly on our ability to perform γ/jet separation (obvious). With present estimates reducible backgrounds are by far not negligible
  - May attempt to separate quark from gluon jets (see Orsay's talk last meeting). Working on it
  - May attempt Neural Networks implement new variables… (see K.Loureiro's talk)
- If reducible backgrounds are still large we'll have to think. Re-summation effects cannot be neglected
  - However, re-summation effect on P_T spectrum depends mainly on structure of color flow. Analogies may be used

Strategy for H-> γγ Analysis

- H+2jet (VBF) may be easily decoupled from the rest of the analyses
  - Covers small fraction of phase space
  - Dominant systematic errors are of different nature
- Inclusive and H+1jet have lots of overlap
  - However, H+1jet analysis takes up only 1/10 of the gg->h signal.
    - This fraction may be reduced by tightening the cut on $M_{J\gamma\gamma}$.
  - An optimization procedure need to be applied:
    - Maximize combined significance of inclusive analysis (with $M_{\gamma\gamma}$ and $P_{T\gamma\gamma}$ as discriminating variables) with H+1jet analysis by varying P_{TJ} and $M_{J\gamma\gamma}$. This may be achieved by ordering analyses in S/B

Strategy for H-> γγ Analysis (cont)

- Inclusive and H+1jet have lots of overlap (cont)
  - MC generation of signal and irreducible background may be done with one set of MC samples for the inclusive and H+1jet analyses
    - Double counting may be avoided trivially by preventing the same event from being selected in two analyses
  - The situation with the reducible backgrounds is somewhat more complicated. Our approach will depend on how much better can we perform γ/jet separation
- A back-of-the-envelope estimate of the combined signal significance for 30 fb^{-1} with K factors: 7.4σ for M_H=115 GeV and 9.7σ M_H=130 GeV
  - Have not used improvement from likelihood techniques nor multivariate analyses